DISLOCATION OF THE SHOULDER

By James H. Stevens, M.D.

OF BOSTON, MASS.

DISLOCATION OF THE SHOULDER

By James H. Stevens, M.D.

of Boston, Mass.

There are probably few fields of surgery which have been tilled more intensively than dislocations of the humerus at the shoulder-joint. It would seem as if the last word had been said on this subject and that following the footsteps of Allis and Kocher and Stimson, there would remain few if any new ideas which could be evolved in this old subject. But like many other fields of medicine and surgery it would seem to us that the last word is still a long distance away and that perhaps by an intensive résumé of these old pathological conditions, we may evolve occasionally a new idea which may be of just as much value to the profession as the pursuit of these newer theories, many of which we shall look back upon in later years with tolerant amusement. Most of the old hackneyed subjects will stand a good deal of intensive study, with equal advantage to ourselves, to the profession at large, and to the public. Is there any need for a further study of such a well-known subject as dislocation of the shoulder?

It is difficult to make a patient realize that a dislocation of a shoulder is in reality not a simple matter, and that the effect of such an injury results many times in a permanent loss of power and efficiency to the individual, which can only be reflected in our economic national life, in a loss of productivity when we multiply this individual loss by the number of accidents of this kind. Even the medical profession fails to take seriously a dislocation of the shoulder. What are the facts? Schultz, who can hardly be criticised as an investigator, collected the end results of all dislocations of the shoulder in Kutner's Clinic for five years. There was a total of 160 cases. Some of these cases never returned. Others were excluded because of the complications. There remained fifty-four cases in which there were no complications to the luxation. Late results in these fifty-four cases showed that in only seven was the joint motion free with no pain and no loss of power that was noteworthy and that even in these seven cases, there was a loss of power which was easily measured. In thirty-nine, or 75 per cent. of the cases, there was marked weakness of the arm so as to be noticeable, and in one-half of these, pain was a symptom. These are startling figures and mean either that the trauma is more serious than we have been taught to believe, or that there is something wrong with our treatment. I believe it to be due to a mixture of both, but principally to the fact that in the treatment of dislocation of the shoulder, we have given little consideration to the damage which has been sustained by the supraspinatus and the short posterior rotators and that we have never considered their relaxation as a requisite to their full recovery.

A muscle always has a certain amount of elasticity but it is normally within well-defined limits and these limits are comparatively narrow. A

muscle only recovers its full function after injury if permitted to do so, in the position of relaxation. Unfortunately, Schultz does not tell us how many of these cases presented that most unfortunate feature of all, recurrent dislocation and there are few statistics to help us, but all of us who have made investigation of this subject, know that it will easily reach one-eighth of all the cases.

Classification of luxations of the shoulder seems to be pretty well established and does not show any great variety in any of our so-called accepted text-books of surgery. There are five described varieties:

1. Subcoracoid—the most frequent.
2. Subclavicular—*subjudice*, we believe.
3. Subacromial.
4. Subspinous—very rare.
5. Subglenoid.

The subclavicular if it occurs, which is questionable, is a further forward dislocation than the subcoracoid, and is only possible with great injury. The subspinous is only a little further backward dislocation than the subacromial, but again with greater injury to soft tissue. Subglenoid is only an interrupted anterior dislocation, a half-way dislocation, as it were.

I do not deny that an intense local force would dislocate the shoulder in any direction. If it were sufficient, it could, by fracturing the acromion, produce even a superior dislocation, but such injuries are crushing injuries and the forces producing them are usually too extensive to produce a simple dislocation and this type means nearly always a tremendous crushing injury in which dislocation is secondary to a far greater injury. There is only one type of dislocation at the shoulder-joint, an inferior dislocation primarily and depending on the rotation, external or internal, an anterior or a posterior final position of the head of the humerus.

Consider the anatomy of the shoulder-joint, and the normal abduction of the arm which it is necessary to understand in order to comprehend the mechanics of shoulder dislocation, because the shoulder dislocates always in abduction. It is necessary to a proper understanding of the mechanics of the shoulder-joint, to disregard the capsule of the joint, because the capsule is a loose bag whose function is to manufacture and to retain the lubricating substance of the joint and it is extremely unlikely that it has any other function. It certainly does not hold the head of the humerus in place in any way on the glenoid cavity of the scapula, and only in one position, extreme abduction, is there even tensing of the capsular structure and this only of the inferior portion.

If one has any doubt of this fact, he has only to remove the muscular attachment from the shoulder-joint. Remove the deltoid, the biceps, the coraco brachialis, and the triceps muscles—all of which in the condition of normal tonus tend to hold up the arm. Still the humeral head is held into its socket on the glenoid, but divide the supraspinatus muscle and the short

posterior rotators and the subscapularis, and immediately there is complete relaxation and the head of the humerus can be pulled out of its socket. It will drop out of its socket of its own weight. If we consider the humerus as a lever, it is easy to see that the deltoid cannot start the arc of abduction. This is the function ordinarily of the supraspinatus up to the point where the mean line of the deltoid pull will fall superiorly to the fulcrum of the lever, which is upon the glenoid as shown in plate one. This lever is an angled lever and the supraspinatus from its insertion into the short arm of the lever can start the arc of abduction and keep it going until the line of pull of the deltoid has risen above the fulcrum of the lever so as to be able to exert its pull. A certain amount of pseudo abduction of the arm can be accomplished by the simultaneous action of the trapezius, and the serratus magnus where the supraspinatus and deltoid are paralyzed, but it is only a pseudo abduction which is limited in extent and is only due to the lifting of the base for the fulcrum of the lever, that is, the glenoid cavity of the scapula. The recent contention that active abduction, in its last arc, is due to action of the trapezius is fallacious, and the fact which has been cited as evidence in favor of this contention, that in some cases of paralysis of the spinal accessory nerve, the arm cannot be lifted in abduction beyond the horizontal is due to the loss of action of the trapezius as a stabilizer of the base on which rests the fulcrum, allowing this fulcrum, the glenoid cavity of the scapula, to sink downward to a lower level so that in abduction with the hand in pronation, the greater tuberosity of the humerus strikes against the acromion process of the scapula before the level of the horizontal is reached, whereas in the normal this point is at or slightly above the horizontal, and because the loss of trapezius action makes it impossible for this muscle to turn upward the acromion from 90 to 130 degrees in abduction in order to get it out of the way of the greater tuberosity. This is the middle of abduction, however, and not the last arc.

The scapula has no bony connection with the trunk except through the clavicle and there is a limited motion possible at both the acromio-clavicular and sterno-clavicular articulation and the greatest amount of motion is at the sterno-clavicular joint.

The scapula is a plate of bone with muscular attachments which are connected to it from every conceivable angle and within limits its position depends on the action or over action of certain muscles or groups of muscles. The levator anguli scapulæ is attached to its posterior superior border, the rhomboids to its posterior inner edge, the pectoralis minor to its coracoid process, the trapezius to the entire length of the spinous process, to the acromion and the outer part of the clavicle and the serratus magnus to its anterior inner border.

The other muscles which bind it to the humerus may be for the moment disregarded.

It is evident that here is a bone which possesses very little stability. It is easily movable in any direction, the only check being the limits of elasticity

of these muscular attachments and a very small articular surface which, in itself, possesses considerable motion. Upon this unstable foundation we must remember that we depend for a base for our lever when we consider the humerus as a lever which we must do in a study of the mechanics of the normal abduction of the arm.

Now, let us group these muscles as regards their action so far as the position of the glenoid cavity of the scapular is concerned. Because the glenoid is the base on which our lever rests. A lever is only a lever because it has a base and the base is as important as the lever. If the base is unstable the lever will fail and this base of ours depends upon muscular contraction for its stability. Over-action or loss of action by any particular group of muscles or by any individual muscle will, it is plain to see, affect our base and therefore affect our lever as much as if it were an actual interference with the lever itself. The position of the base will depend upon synchronization of all the muscular attachments.
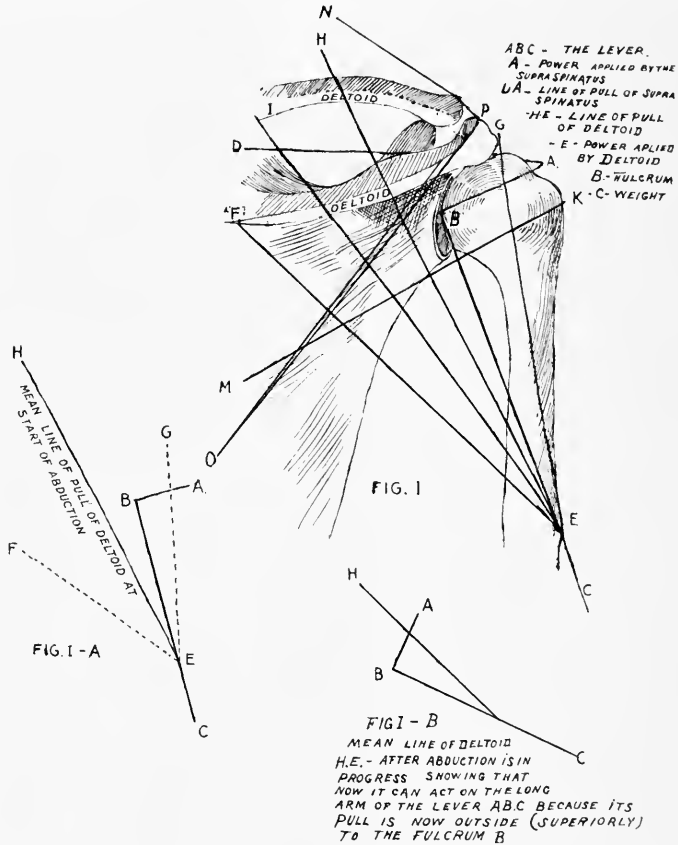
The levator anguli scapulæ tends to pull up the superior posterior angle of the scapula and therefore to tip the glenoid downward. The pectoralis minor will tend also to tip the glenoid downard and the rhomboids not only pull the scapular inward towards the spine, but also tend to tilt downard the glenoid. Against these forces is the trapezius which raises the scapula, especially the acromion as in shrugging the shoulders, and from its oblique insertion, the superior portion not only raises the acromion but tilts it upward and therefore tilts upward the glenoid as well. This muscle acting by its inferior fibres has an exactly opposite effect, but it is an established fact that this muscle acts through separate bundles which are separately innervated and we are especially concerned as regards abduction with the action of its superior portion. The serratus magnus tends to swing the outer portion of the scapula backward as in the military position of the shoulders and also has the ability to swing outward the scapula thus tilting upward the glenoid cavity.

The trapezius raises the shoulder, that is, it raises the acromion process of the scapula and the clavicle, the whole moving upward on the sterno-clavicular joint as a hinge and together with the serratus magnus it rotates the scapula outward from the side. These two muscles acting together raise the base of the lever and steady it at a higher level, thus permitting the continuance of abduction between 90 and 130 degrees. It is evident by the obvious outward swing of the inferior angle of the scapula. But above this point the restriction is absolute in the usual type of normal abduction. The level of this locking is individual and varies within considerable limits, and it is a fact that there are certain individuals whose external tuberosities are small or the space between the tuberosity and the tip of the acromion is greater than in the ordinary type, thus allowing them to lift their arm in the position of abduction with the hand in pronation to a much higher level, but this is not the ordinary type.

Figure 10 gives the view of a man, who, normally, can abduct his arm with his hand in pronation to the side of his head, that is, 180 degrees. Why?

The greater tuberosity of the humerus in his case comes in contact with the tip of the acromion when his arm is at 90 degrees of abduction and from this point the inferior edge of the scapula can be seen to swing outward as the acromion is pushed upward by the greater tuberosity or lifted upward by the action of the trapezius and serratus. At 130 degrees, however, the scapula ceases to move outward to any great extent, the greater tuberosity is felt to

FIG. I.—Showing the lines of pull of the fibres of the deltoid providing these fibres acted together, H-E being approximately the line of such pull showing that in this case it could not act on the lever A-B-C to abduct it. Assuming that the acromion portion of the deltoid acted as a separate muscle or as a separate contraction, then it could (consider the line G-E and its effect acting at E on the long arm of the lever A-B-C) aid in starting the humerus upward in abduction, but should the fibres act simultaneously, the line of pull would be inside the fulcrum B, and provided it was in contraction, it would act in opposition to the line of pull of the supraspinatus, D-A. In order to act on the long arm of the lever, the line H-E must fall outside the point B (fulcrum), and this is possible only after the long arm of the lever (the humerus) has been partially abducted, which is done up to this point by the supraspinatus D-A acting at A on the short arm of the lever A-B-C, A the power, B the fulcrum, and C the weight of the arm to be abducted. K-M shows the line of pull of the short rotators causing external rotation, especially pronounced once there is a fracture of the surgical neck putting out of commission the opposition of the pectoralis major and latissimus dorsi and teres major muscles. The trapezius N-P-O is inserted into the area of the clavicle and spinous process which is shaded above the deltoid origin, and if the superior fibres represented by N-P acted separately, it is clearly seen that it might raise the glenoid to a higher position. This action would also be accentuated by the action of the serratus magnus, which would also tilt upward the whole scapula, and therefore, raise the glenoid. But neither would have any influence in direct abduction except by raising this base on which the fulcrum rests. Likewise, it is obvious that if the upper fibres of the trapezius were paralyzed, the antagonists would tend to tilt downward the glenoid. The pectoralis minor especially would tend to do this, and it would be aided by the levator anguli scapulæ and the rhomboids. The lower fibres of the trapezius, however, are not elevators but depressors of the scapula P-O. Even with a paralyzed trapezius, it must not be forgotten that much of this tendency to sag would be counteracted especially under effort by the serratus magnus muscle. With a paralyzed deltoid and a paralyzed supraspinatus, if the triceps, the biceps and the short rotaters or enough of them were intact so as to lock the scapula and humerus together, the action of the trapezius upper fibres and the serratus magnus would enable the patient to move outward the arm, but it would be the first arc of abduction and not the last, and it would not be a free, easy abduction at the scapulo humeral joint. It would only be a swinging outward of the locked entire shoulder girdle and it would be limited. It would be analogous to the abduction, which is possible with an ankylosed shoulder. Many muscles have individual action of their various parts, and this applies to the trapezius and to the pectoralis major.

FIG. I

ABC - THE LEVER.
A - POWER APPLIED BY THE SUPRA SPINATUS
DA - LINE OF PULL OF SUPRA SPINATUS
HE - LINE OF PULL OF DELTOID
E - POWER APPLIED BY DELTOID
B - FULCRUM
C - WEIGHT

MEAN LINE OF PULL OF DELTOID AT START OF ABDUCTION

FIG. I - A

FIG 1 - B
MEAN LINE OF DELTOID
H.E. - AFTER ABDUCTION IS IN PROGRESS SHOWING THAT NOW IT CAN ACT ON THE LONG ARM OF THE LEVER A.B.C BECAUSE ITS PULL IS NOW OUTSIDE (SUPERIORLY) TO THE FULCRUM B

slip under the acromion even with his hand in this position of pronation and he continues to abduct to 180 degrees. The trapezius has simply raised the acromion up in order to give more room for the rotating head and when this

is accomplished and the head is able to rotate under the acromion its further action is synchronous with that of other muscles of the scapula in the holding of the glenoid firmly in its raised position.

Consider the active part of the lever, so far as abduction is concerned. Figures 1 and 2 will explain much of the mechanics of active abduction. Abduction is somewhat of a misnomer. Do we mean abduction in pronation or abduction in supination? Abduction in pronation which is what we usually mean by the term "abduction" is in the ordinary individual due first to the action of the supraspinatus which starts the motion. Then the deltoid goes into action and continues the abduction of the arm. Even with the supraspinatus paralyzed, the arc of abduction may sometimes be started, but this is done only by locking the humerus and scapula together by muscular action and using the trapezius and serratus magnus to lift up the base and to swing outward the whole locked structure.
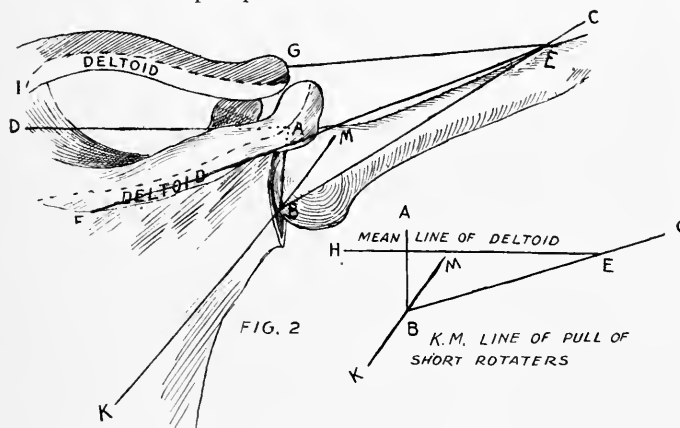

FIG. 2.—This shows the lines of pull of the deltoid when the arm is partially abducted. G-E, F-E and I-E and the line of pull of the supraspinatus D-A acting on the short arm of the lever A-B-C, while the deltoid acts on the long arm of the same lever, its power being applied to E, a point between the weight C and the fulcrum B. Note also that both lines of pull, deltoid and supraspinatus, are above the fulcrum B and unless there is another force applied the fulcrum of the lever would be unstabled and render worthless any amount of power applied. That force K-M, a line of pull of the infraspinatus, and teres minor behind and of the subscapularis in front is supplied by these three short rotaters without which the head of the humerus would slip upward, answering the pull of the supraspinatus and deltoid. Note that the line of pull of the short rotaters passes through the fulcrum B, therefore, it acts merely as a tractor and exerts no force either on the long or short arm of the lever, consequently offering no impediment to the abduction, while at the same time rendering such action possible by keeping the fulcrum firmly in place.

It is not the normal easy abduction of the arm from the glenoid and it is extremely limited. Figure 1 shows the supraspinatus action and the deltoid action both pulling the arm upward in abduction, the tendency would be to pull the head of the humerus, so that, if this force continued without restraint the head of the humerus would be pulled up against the under surface of the acromion and there would begin to be restriction to the normal arc of abduction when the humerus had swung upward to 40 or more degrees. The arm is therefore a lever with an unstable fulcrum and the bone slips and abduction is impossible. A lever is only efficient if it has a fulcrum that is stable as well as a base. A slip of $1/_{100}$th or $1/_{1000}$th of an inch would be as fatal to its efficiency as a greater one. There must be another force or pull here at a different angle than either of the forces which we have considered; a force which will oppose this tendency to upward displacement of the abducting head of the humerus and pull it down-

ward, at the same time not impeding the rotation of the head and this force is supplied by the short posterior rotators behind and the subscapularis in front, forming a veritable sling about the head of the humerus pulling it downward away from the acromion and fixing it firmly into its place against the glenoid cavity of the scapula. Figure 2 shows the line of pull of the short rotators of the shoulder such as to hold the head of the humerus in its place on the glenoid. Inasmuch as the line of pull falls through the fulcrum, it does not obstruct the movement of the abduction in any way, and by pulling the head of the humerus firmly into place and keeping it there, it prevents riding up of the head under the acromion, while at the same time helping to lift the acromion and makes abduction a possibility. Remove from this lever these short rotators, either by operation or paralysis, and with the deltoid intact, and the supraspinatus acting, the man will not abduct his arm beyond 45 or 50 degrees, and only then by a tremendous effort. So that this sling of elasticity, about
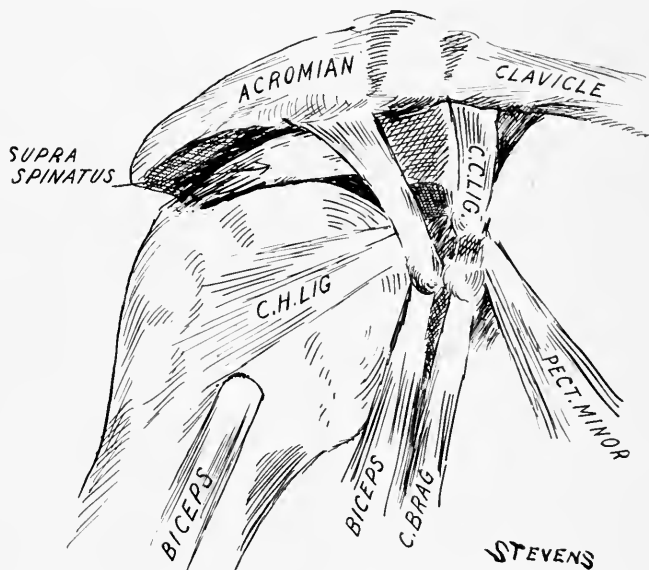

Fig. 3.—This view shows how impossible a sub-clavicular position of the dislocating head would be without other injuries greater than the dislocation. In order to reach that position, the head would either have to come through between the two heads of the biceps and then ride over the coracoid or under the short head of the biceps and coracoid. The first way, the subscapularis, the infraspinatus and the teres would all have to be ruptured and the coraco acromion lig. and supraspinatus probably. If the head came out as it does under the short head of the biceps and coraco brac. either these two muscles would have to be ruptured or the coracoid process fractured in addition to the pathology stated above in order that the head should become sub-clavicular.

the neck of the humerus is of as much importance to the normal abduction of the arm as a functionating deltoid or supraspinatus muscle.

It is necessary to remember that this external rotation movement of the humerus which seems so easy to execute, is accomplished by the infraspinatus and teres minor muscles overacting as compared with the subscapularis; nevertheless, at the same time, these three muscles must keep up their tension in order to keep the fulcrum of the lever, the humeral head, firmly in the glenoid. If they relax for an instant, this steady elastic pressure, the lever fails, and down will go the arm to the side. A deltoid as strong as a lion's paw would only make matters worse, because a lever is only as stable as its fulcrum. (See article on action of short rotators in the *American Journal of Medical Sciences* of 1909.) This is exactly what does take place

in these cases of a paralysis or partial paralysis from injury of the short rotators. The head of the bone rides and while the patient can abduct up to 45 or 50 degrees, then comes restriction. The short rotators paralyzed, or if not paralyzed, sometimes refusing to function because of tenderness in their injured tendons, or from tenderness in the floor of the bursal sack, which is directly above them, refuses to work. The presence of calcareous deposits in these tendons, as well as in the tendon of the supraspinatus, is usually the evidence of old injury and will be found oftener in those patients who have at some time suffered from an old dislocation at the shoulder-joint, or an old injury which has caused straining of these tendons.
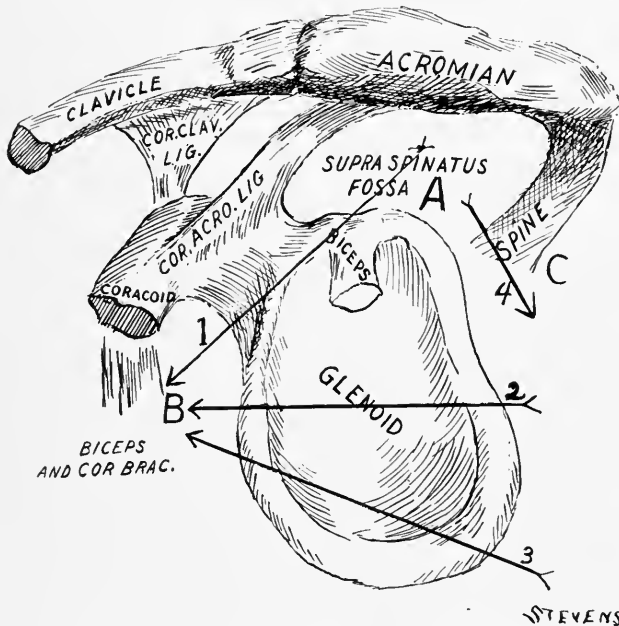

FIG. 4.—Shows by arrow 1, the increase of distance the supraspinatus would traverse if dislocated anteriorly under the coracoid, and how impossible it would be without rupture of this tendon and many others to further dislocate the head of the humerus under the clavicle. Arrows 2 and 3 show the greater distance which would have to be traversed by the infraspinatus and teres minor, in order that the anterior dislocation should be possible. The tendons would be under great strain across the empty glenoid. Impossible for the head to go further anterior under the clavicle without rupture, and also a broken coracoid or ruptured biceps and coraco brachialis. Even then the subscapularis would prevent it. Arrow 4 shows shorter distance of supraspinatus to its new position at C in posterior type of dislocation.

In the ordinary type in abduction, in pronation, the greater tuberosity strikes against the lower side of the acromion when the arm has swung up to about 90 degrees and further motion is impossible, except as the acromion process is lifted, the entire scapula rotating outward. The trapezius which is the shrugging muscle of the shoulder, rotates the scapula and lifts it up in order to increase the ability of the head of the humerus to rotate under the acromion. The serratus and the short rotators aid in this same movement and the clavicle rises also. They fix the scapula firmly in this raised position and this being the base of the lever, permits the degrees of abduction between 90 and 130 degrees, while they do not actually abduct. Here again comes restriction. There is restriction because the greater tuberosity still impinges upon the tip of the acromion process and the acromion has been tilted to its limit. Further motion is impossible. Now, by externally rotating the humeral head so that the hand is in supination, the groove in the humerus between the greater and lesser tuberosities comes into line with the tip of the acromion

and there is just clearance enough to permit further abduction as the greater tuberosity rotates under the acromion, and in both types when the tuberosity rotates under the acromion, the scapula ceases to turn outward to any great extent. The clavicle ceases to rise at this point, which it would not do if this further action were due to the trapezius. The further swing of the inferior tip of the scapula is less pronounced and what little there is, is decidedly forward, instead of directly out. In some cases the turning is nil, once this point has been reached.

The muscles which accomplish the last arc of abduction especially with the hand in the position of supination, which is necessary for the completion of abduction in the vast majority of cases, are the deltoid, the biceps, the pectoralis major, and the triceps. How can it be otherwise? The biceps runs across two joint surfaces and therefore it f l e x e s both. The t r i c e p s runs across one movable surface, and by its action it keeps the forearm in a fixed p o s i t i o n, therefore making a fixed point upon which the biceps can exert its action, without flexing t h e forearm, in this way
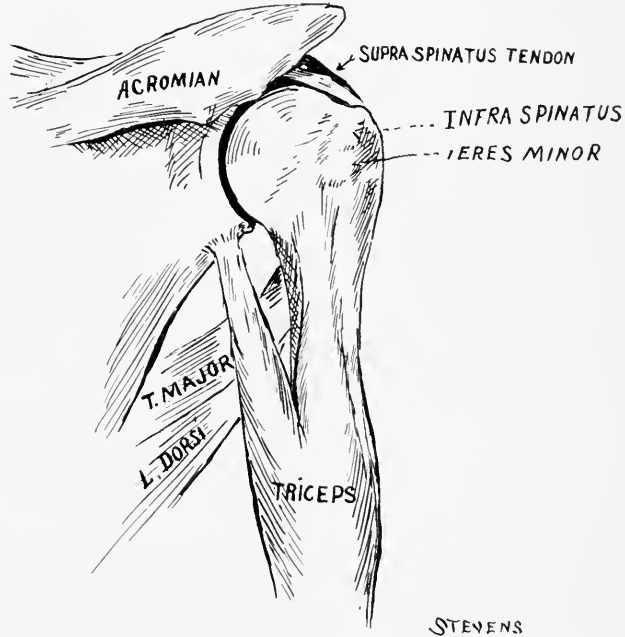

FIG. 5.—This figure shows the lessened strain, both on the supraspinatus and infraspinatus, and teres tendons, which would result once a posterior dislocation had occurred. The strain in this form of dislocation obviously would fall upon the subscapularis tendon in front, except for the immediate strain thrown upon the supraspinatus at the time of dislocation. This figure also shows the well protected surface of the joint from behind if we reconstruct visually the infraspinatus and teres minor.

transferring all its action to the shoulder. This action is, however, limited.

The pectoralis major runs across the upper joint and the clavicular portion innervated from the fifth cervical root, becomes an abductor of the humerus after the arm has swung beyond the horizontal. After the arm has swung upward to 130 degrees if one will note its strength of contraction, he will conclude that it is a tremendous abductor, and it constitutes, together with the deltoid which is still able to function, after the tuberosity has rotated under the tip of the acromion or after the tip of the acromion has been lifted and rotated out of the way by the trapezius and serratus, the main power in abduction in its final arc.

The trapezius and the serratus magnus from now on are only fixers,

stabilizers of the scapula, but they have a very limited action except between 90 and 130 degrees so far as abduction of the arm is concerned. Almost as much can be said for all the other muscles attached to the scapula but nevertheless they are not to be termed abductors.

A dislocation of the shoulder anteriorly, that is, a primary dislocation of the shoulder, without first being an inferior dislocation, is an impossibility except perhaps as we have said, rarely as the result of an extreme local force in which the dislocation would be secondary to a tremendous crushing and tearing lesion. The same objection applies to a posterior dislocation. There is no such thing except as applies also to the anterior in the face of an overwhelming local crushing force. The rent in the capsule usually runs up as high as the coraco-humeral ligament, which runs across anteriorly from the coracoid process to the humeral head, and is in reality a thickening of the capsule. The capsule is always torn away from the glenoid rim and never from the humeral head. Why? Because the head of the bone in the position of abduction is tensing the inferior portion of the capsule, and as external
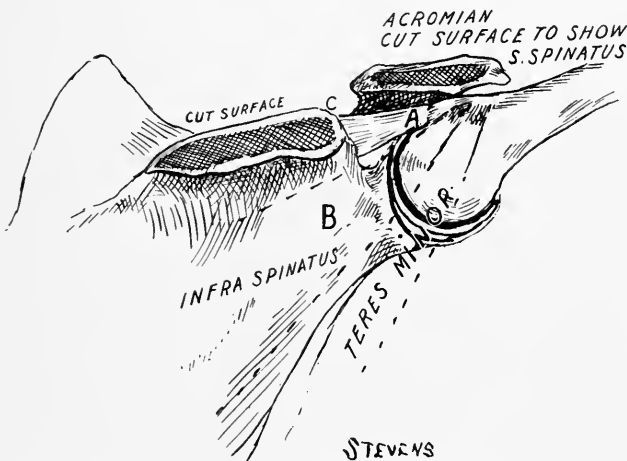

FIG. 6.—The acromion has been cut so as to show the insertion of the supraspinatus from behind. Note how well protected the posterior surface of the joint would be by the tendons of the infraspinatus and teres minor. This drawing also shows how these three muscles keep the head of the humerus against the glenoid, at the same time allowing abduction. In a posterior dislocation, note that the distance from C to A, normal position, would not be increased if A were transposed to B, the position of posterior dislocation, while the infraspinatus and teres minor would be relaxed.

rotation comes, the head of the humerus brings local pressure to bear against a comparatively weak structure. This is the only portion of the capsule which is tensed under any condition and the direct pressure of the dislocating head is exerting local pressure against it. Were it a very strong membrane, it might tear anywhere but not so with a comparatively slight structure.

The normal abduction of the arm with the hand in pronation and with the arm in internal rotation, which is the position which one assumes when one falls, proceeds up to a certain point with ease, until well above a right angle where it is arrested. The greater tuberosity of the humerus goes bang up against the outer projection of the acromion process of the scapula. The scapula is forced upward by this force, but this upward motion is limited. If the force continues, the greater tuberosity is broken, the neck of the humerus is broken or, which rarely happens, the tip of the acromion breaks.

If a man fell with his arm in this position, the hand in supination, his humerus would go smash up against his head and he would not break his shoulder and he would not dislocate his arm; but he does not fall like that. One falls with hand in pronation and arm in internal rotation, in order to save himself, and so the greater tuberosity impinges on the acromion process. The reason that a greater number of breaks of this type do not occur is this additional lifting of the scapula on the clavicular sternal and acromio-clavi-cular joints to the limit of elasticity permitted by the muscular attachments of the rhomboids, the p e c t o r a l i s minor, the levator anguli sca-pulæ and the rhomboid liga-ment the action being of the same nature as the recoil mechanism of a gun.

If all these structures hold and there is no break or even if the break in the greater tuberosity which frequently happens, is not enough to release the pressure, the force continues. The pressure of the tip of the acromion is trying to push the humerus into external rotation and re-lease it. If this were a slow process, it would accomplish its task. It also acts now to force the head of the humerus not only downward, but to lift it out of the glenoid cavity, because for this stress a new lever with its fulcrum on the tip of the acromion, is estab-lished and where the head has

FIG. 7.—Shows dislocating head of humerus just coming through the capsule in anterior dislocation. Note the circum-flex nerve directly over the head in this position of abduction of the arm. Is it any wonder that paralysis of deltoid follows so frequently? Note that this nerve and to a lesser extent the musculo-spiral are more fixed in position because both pass under muscular structure and through layers of restricting fascia, which binds them down so that a stretching is more ser-ious than in the others. In the order of their fixity, these nerves are the circumflex, the musculo-spiral and the musculo-cutan-eous, and, therefore, these three are more likely to be injured by strain. In the position of abduction the musculo-cutaneous is superior and, therefore, above the major strain imposed by a dislocating head, in most cases. The head of the humerus has come out in some cases even between the two heads of the median. Visualize, in such a case, what a leverage reduction might do.

partly rotated under the acromion, the leverage is transferred to the neck of the humerus and often results in a fracture of the neck of our Type II class: See "Fracture of the Upper End of the Humerus," ANNALS OF SUR-GERY, 1919.

The supraspinatus muscle is not tense but is relaxed and the head of the humerus slides downward and the inferior portion of the capsule is tensed. Even now the head of the humerus would not dislocate even if the capsule tore in the majority of cases. But just at this instant when the head of the humerus is forced downward to rest on the inferior rim of the glenoid,
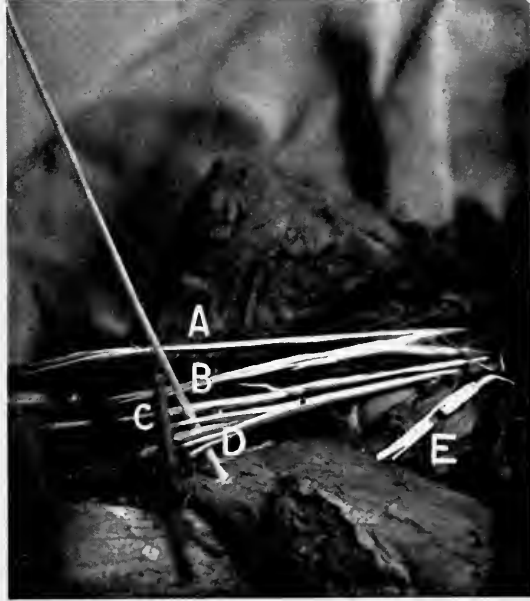
literally lifted on to the glenoid rim, comes the movement of external rotation, not half-way, but extreme external rotation, and the head is twisted out of the glenoid and through the inferior torn portion of the capsule. If you have ever externally rotated an arm from which the pectoralis major muscle has been removed, you will be impressed at the way in which the head of the humerus will rotate to the front of the glenoid and become prominent. Once the head of the bone has slipped out of the inferior rim of the glenoid, the future position of the head depends entirely upon the position of the arm as regards rotation. If in external rotation, which is the position which all the forces tend to produce nine times out of ten, the force of the acromion pushing on the greater tuberosity, or on the neck if the tuberosity has succeeded in slipping under, the force against the elbow and forearm externally as the man falls on his side, as he does naturally, all tend to further externally rotate the humerus.

Result, a humerus whose position in abduction and leverage against the acromion, the arm being in internal rotation has withstood the hammer blow against the process without f r a c t u r e of the greater tuberosity and without fracture of the neck of the

Fig. 8.—This represents a type of fracture which is fairly common with dislocation of the shoulder. It is an impact separation of the greater tuberosity, and is not due to the same mechanics as that represented by Fig. 9, which is a periosteal tear from tension on the tendon. These two types are the most common complication in injury from dislocation.

humerus. It has been forced downward on the glenoid and by force of leverage against the head by the acromion the gliding surface of the bone has been lifted as well as forced downward on to the glenoid rim. External rotation, normal external rotation which would have permitted the normal depression in the humeral head between the greater and lesser tuberosity to come into line with the tip of the acromion process and so have permitted hyper-abduction and freedom of motion, thus releasing the pressure, has failed to materialize in time and then too late has come with extreme force. It is the last straw and out goes the head of the bone and the resulting discolation is a subcoracoid dislocation of the humerus. If exactly

at the moment when the head of the humerus is on the inferior rim of the glenoid, there is the unusual force of extreme internal instead of external rotation added, the resulting twist inward of the head of the humerus will have a tendency to force the articular surface backward and there will result either a subglenoid, in which the force of internal rotation has been small and only enough to counteract the tendency for the head of the bone to slip forward under the coracoid, or a still rarer type, a sub-acromial dislocation.

A dislocation of the shoulder anteriorly, especially, is an impossibility without putting a s t r a i n upon the tendons of the supraspinatus, the infra-s p i n a t u s, and the teres minor. If the dislocation is the subcoracoid one, which is the most common form, the distance from the origin of the supraspinatus to the new position of the greater tuberosity of the humerus under the coracoid is clearly greater in distance than in the normal position, and the tendon of the supraspinatus is also angled over the rim of the empty glenoid. See Figs. 3 and 4. Codman reported a number of cases of rupture of the supraspinatus tendon from being caught between the greater tuber-osity and the acromion and while at the time we accepted that explanation, we have

FIG. 9.—This shows a type of lesion as common to disloca-tion as the type showing a definite separation of the greater tuberosity. The mechanics are different, however. This repre-sents a periosteal tear of the insertion of the supraspinatus, and is caused by the strain on this tendon, usually at the time of dis-location. Undoubtedly, in a leverage reduction, it might also occur, but it usually takes place at the time of dislocation and is more common in the anterior types.

become more and more convinced that the supraspinatus is rarely or never caught between these bony prominences, but that it is the force producing a dislocation that causes rupture of this tendon. That is a rupture of the tendon *per se,* or a periosteal tear, and not a separation of its insertion into the greater tuberosity by a fracture which occurs frequently from impact on the acromion process as I have shown in a recent article (ANNALS OF SURGERY of 1919) (Fractures of the upper end of the humerus). We may, I think, assume that in every case of dislocation of the humerus and especially in anterior dis-

location, there is injury to the tendon of the supraspinatus, and that often it is ruptured. If the discolation is further forward, a so-called subclavicular dislocation, if such exists, it is always ruptured. Otherwise, it would be impossible to put the head of the humerus in this position.

The infraspinatus and teres minor muscles are posterior and run outward from the posterior surface of the scapula to be inserted into the greater tuberosity of the humerus to complete with the anterior muscle, the sub-scapularis, the sling about the head of the bone which under tension makes it possible for the deltoid to abduct the arm. We have shown that if these are paralyzed or if they are injured or do not work smoothly the deltoid can only abduct the arm with difficulty and often not at all. Forty-five to fifty degrees of motion is possible and then restriction. Not from pain, not from any inability of the deltoid to do its work, but simply and solely because these short rotators refuse to work. The sling about the head of the humerus is not efficient and the head is not held firmly against the cavity. The same phenomenon will take place when a subscapularis tendon re-fuses to work, thus destroying the sling anteriorly, but injury to the subscapularis, except as a part of a brachial plexus paralysis is not so common as an injury to the posterior short rotators. In one case of ours,

Fig. 10.—Shows abduction in pronation. This type can abduct in this position to the side of the head. The outer end of the clavicle ceases to be raised, however, when 130 to 135 degrees has been reached. If the final arc beyond 135 degrees were due to trapezius action, this would not be so.

following an injury, not a dislocation, there was a paralysis of the subscapu-laris muscle, as a part of a paralysis which involved the latissimus dorsi, the pectoralis major, and minor tendons. The trapezius and the serratus were intact. The arm was externally rotated, therefore the infraspinatus and the teres minor were intact. The arc of abduction could be started, therefore the supraspinatus was intact. The deltoid took up its work and the arm could be abducted by strenuous effort, fifty to sixty degrees, but the weight of a finger placed upon it would send it down and beyond this it would not go.

Here we have identically the same result as before, the sling about the head of the humerus which is necessary to abduction, is out of commission. But this is rather unusual. In these cases of dislocation anteriorly, it is the posterior rotators which are injured exactly as the supraspinatus is injured, and oftentimes they are ruptured. The distance from their origin to their

97

insertion on the greater tuberosity of the humerus in the position of sub-coracoid dislocation, is much greater than normal and these tendons are pulled straight over the posterior rim and inferior edge of the glenoid. They are tense and they are always injured, sometimes more and sometimes less and reacting to injury even if not entirely ruptured, they are inflamed and never again are they exactly the same smooth resilient tendons which they were before.

Any substance which is elastic or expansile and that has suffered a strain which is greater than its tensile strength is never fully recovered from. This applies to rubber or to steel or to iron or to muscle. It is one of the under-lying principles of mechanics. In these anterior dislocations, the subscapu-laris is not tensed. If anything it is relaxed. Leave the head of the bone out for a short time and you will have a tense subscapularis from contraction; so tense in old cases as to require division before reduction can be accom-plished, but not in fresh cases. In a subcoracoid dislocation, the short head of the biceps and the tendon of the coraco-brachialis are pushed forward over the head and tensed also. The long head of the biceps is usually lax across the joint and there is plenty of play so that usually it is not ruptured. In these mild cases the head of the humerus is hardly off the glenoid anteriorly.

Anything which relaxes the biceps and coraco-brachialis and gives the bone a push upward and posteriorly is enough to reduce it. What we actually do by Kocher's method of reduction is to relax the biceps and coraco-brachialis and by external rotation to use the posterior side of the greater tuberosity against the anterior rim of the glenoid to lift the head and then by carrying the arm across the front of the chest keeping the prying leverage of external rotation, we also lever it against the coracoid and the head of the bone slips up on the glenoid rim. It is a double leverage and a lift and not as has been said by using the posterior portion of the capsule wound about the head and neck to draw it into place. How by externally rotating the head of the bone, the small amount which one does, can you wind the posterior capsule about the neck of the humerus? What you do by external rotation is to produce exactly the position of the capsule as when the accident happened, and if the bone came out of the capsule in that position, it can equally well go back if you reproduce the same condition backwards. If anything you will unroll the posterior portion of the capsule instead of tensing it, and this is exactly what you wish to do, and a little push upward and backward at the same moment that you swing the arm across the chest will help you tremendously after the capsule is unrolled and the rent made bigger. The worst thing that can be said about it is that it is reduction by leverage, the force being applied on the long arm of a lever of the first class, power, fulcrum, weight and a tremendous leverage is obtained which improperly used can also do a tremendous amount of damage. If you properly interpret the condition, the greater tuberosity being against the anterior rim of the glenoid, where it can be used to lift the head by external rotation of the arm,

you will succeed. If anything interferes and the head does not rise to the glenoid, you may tear your muscles more and you may even fracture the humerus or the coracoid thus creating greater trouble than you are trying to correct. If the head has pushed further along under the coracoid you will usually not reduce it by this method. Because the head of the humerus is too far away from the glenoid, and you cannot use the greater tuberosity against the glenoid rim as a fulcrum for your lever and it is wedged. Besides, in these cases, the muscular attachments, the supraspinatus, the infraspinatus and teres minor, are many times ruptured and they do not help as a fixed point against which resistance can be applied. The posterior capsule may be torn less in these anterior cases than in the posterior, but the reason that the head of the bone goes round and round as described by various writers is that it is too far away from the rim of the glenoid and there is rupture of these tendons, especially the supraspinatus and the infraspinatus and teres. The answer is abduction after flexion of the forearm to relax the biceps and coraco-brachialis and allow the head to slip back under these muscles which may hold it. First flexion, second abduction, because the arm went out in abduction; third, traction to pull it outward; fourth, external rotation to increase the hole in the capsule; this was the way it happened and if it went out that way, it can go back that way. Lastly, external rotation and traction having pulled it back to the rim of the glenoid, traction being kept up all the time, with one hand over the neck of the scapula and the fingers under the neck of the humerus, lift the humerus as the arm is swept downward across the front of the chest, external rotation thus being changed into internal rotation and the bone will traverse the same pathway which it followed in producing the injury but exactly reversed.

By flexion, we relax the muscles over the head. By traction in abduction, we lift the head from under the coracoid. The subscapularis is already relaxed and we get the posterior edge of the gliding surface up to and on to the rim of the glenoid. By external rotation we relax the infraspinatus and teres minor and increase the size of the rent in the capsule. By local pressure upward and backward with the hand, we help the head of the bone over the rim and by changing into internal rotation, we tense the infraspinatus and teres when not ruptured just at the moment when we need their action to pull the head backward. If they are ruptured nevertheless we lift the head into place, and internal rotation carries the head backward toward the posterior surface of the glenoid, just as external rotation has a tendency to bring it towards the anterior portion.

In the subclavicular form, if such a form really exists (I have never seen one) the injury must be much greater in extent. If the head of the humerus comes out of the glenoid and comes to rest under the short head of the biceps and coraco-brachialis, as it does in all the cases that I have seen, then in order to become subclavicular it can only do so by rupture of the short head of the biceps and the coraco-brachialis or fracture of the coracoid. The

pectoralis minor is also in the way and a tremendous tearing of all these structures or their rupture is necessary in order to place the head of the humerus in any subclavicular position. Assuming that the head was anterior to the short head of the biceps and had come through between the two bicipital heads, as it would have to do to be in that relation, it would nevertheless be impossible to reach a position under the clavicle without tremendous tearing of muscles and tendons. The supraspinatus in most of these cases would have to be torn, the infraspinatus and teres minor always, and the subscapularis also and an injury of this nature is rather difficult to imagine. I prefer to think that it is at least a very rare form, if it exists at all, which I doubt. At any rate, if such a position does occasionally happen the only efficient reduction would be by abduction and traction as the first part of the procedure. Try it on the skeleton and visualize the damage to the soft parts. It cannot reach the subclavicular position above the coracoid without the fracture of that process and the subscapularis would prevent its going far in that direction even if the coracoid were broken, and the posterior short rotators ruptured. It cannot reach that position from under the coracoid and the tendons of the coraco-brachialis and short head of the biceps except by fracturing the coracoid or rupturing these tendons. If any man has a plate representing such a dislocation I should like to see it.

Posterior Dislocation, Subspinous, Subacromial.—The capsule is apt to be torn more than in the anterior type. It has been said that the infraspinatus and teres minor are often torn but fortunately this is not as true for posterior as for anterior dislocation. Posterior dislocations are simply a variation of the inferior dislocation due to the sudden strain of internal rotation thrown upon the humerus at the moment when the head of the bone is sliding over the inferior rim of the glenoid fossa. The arm is in abduction exactly as it is in anterior dislocation. Up to the moment of actual dislocation the movement is as we have said; abduction, a slipping down of the head on the glenoid, aided by the prying of the greater tuberosity against the acromion, then comes internal rotation instead of external rotation, as in anterior dislocation and the head of the bone goes out and comes to rest posteriorly. The supraspinatus tendon is necessarily stretched as the head slips down and out of the glenoid exactly as it is in the anterior type, but after it has posteriorly dislocated, the distance to its new position is hardly greater than in the normal position. By referring to Fig. 6, the normal position of the insertion of the supraspinatus at A, would hardly be much increased if changed to the dislocated position at B, and the only injury which the tendon would sustain would be at the moment of its dislocation, or a damage to its insertion on the greater tuberosity of the humerus by the impact of abduction against the acromion. This very often happens, the greater tuberosity being split loose together with the insertion of the supraspinatus, the infraspinatus and the teres minor. The danger of damage to the tendons of the infraspinatus and teres minor is much less in posterior dislocations, as can be readily seen from

a glance at Figs. 5 and 6. The subscapularis may suffer, however, since it is put on the stretch more in the posterior form and if so, we have exactly the same condition of injury to the humeral sling as we had in the anterior form from damage to the posterior rotators; but there is a greater tendency for this muscle to slip under the glenoid, thus saving itself from a certain amount of strain, stressed often, but seldom ruptured. The further out the head of the humerus is under the spine the greater the likelihood of rupture of tendons.

The reduction of this type is by a reversal of the methods by which the dislocation happened. Flexion of the forearm is, however, not so important as in the anterior type because the biceps and coraco-brachialis are not tensed. The important movements are abduction, traction, internal rotation to widen the rent in the capsule, and lastly when the head of the bone has risen to the glenoid rim, local lifting and external rotation and bringing the arm down to the side.

Stimson's position of a hanging arm with ten pounds attached to the wrist, accomplishes this reduction in much the same way, both for anterior and posterior dislocation, but he does not flex the arm which is a distinct advantage. He does not advocate the rotation, and rotation is a distinct advantage which can easily be added to his method, and it then becomes a reduction, practically the same as we use: hang the weight on the flexed elbow and not on the wrist.

Now we have reduced our dislocation, whether anterior or posterior, and what do we do? We put the arm into internal rotation. We put on a sling and a swathe at least, but always in internal rotation. The patient has only suffered a dislocation of the arm. It has been reduced. He can see no reason for being in bed and he insists on going about. If the damage has been little he comes out fairly well, with from ten to twenty days of restriction of motion depending upon the surgeon who treats him, but full recovery is many times not attained and recurrent dislocation is common. Much of this subsequent trouble is due in our opinion to the position in which one treats these primary dislocations of the shoulder after reduction. Internal rotation twists the head of the bone inward and keeps on stretch the already overstretched infraspinatus and teres, and keeps them apart if they are actually ruptured. The position of the arm at the side allows the full weight of the arm, and it is no inconsiderable weight, to fall, not alone upon the deltoid, but upon the supraspinatus muscle, already overstretched and perhaps ruptured. If ruptured, the head of the bone falls away from the acromion as can be demonstrated by the X-ray if taken in the standing position, and the healing of the damaged muscle or tendon, like healing of the damaged muscles or tendons of the infraspinatus and teres minor is permitted to go on in this position of overstretch. If they are simply overstretched, a good deal of recovery is certain. The result is that in most cases, these muscles never fully recover their tone. Their tendons never fully recover that smooth action

which is theirs from the normal elasticity of uninjured muscle fibre. There are oftentimes deposits from an inflammatory reaction in the tendons under the bursa; there is scar tissue which prevents smooth action, there is an instability of the shoulder and a tendency to recurrence of the dislocation, simply because these muscles have healed in an overstretched position and the weight of the arm never allows them to recover their normal tonus again.

Scar tissue never has the resilience of normal tissue. All these cases of dislocation of the shoulder anteriorly should be treated by abduction and external rotation for a period of not less than ten days and often more, and then gentle passive and active motion, and if so treated we shall see the passing of this tremendous number who develop recurrent dislocation.

In the case of the posterior dislocations, external rotation is not of so great an importance as in the cases of anterior dislocation, because the posterior short rotators are much less apt to be injured, but the supraspinatus is injured in both. The position of abduction not only relaxes these muscles, but it permits of the drainage of the joint itself through the rent in the capsule, and this joint is always traumatized and full of fluid. By the raising of the arm in abduction, and rotation, the capsule itself is straightened out as it were, and by gentle passive motion through a few degrees of arc only in these first days, the joint empties itself of the products of this inflammation through the capsular rent into the surrounding tissue where its absorption is more likely than when confined within the capsule. Synovial membrane is never an absorbing membrane. The edges of the torn capsule in this position are brought together without infolding and repair is rapid. Ten days in this position, or in some cases of exceptionally severe injury longer, and after that a sling to lift the elbow up and prevent sagging by the weight of the arm upon these injured muscles. Recurrent dislocations at the shoulder-joint are due always to more or less tearing of the supraspinatus, the infraspinatus and teres minor and more rarely of the subscapularis and their subsequent repair by scar tissue in the position of stretch. Dropping of the head of the humerus is due always to extensive injury of the supraspinatus muscle and not to the deltoid injury. The deltoid, while a very strong muscle is of long muscle fibre, and muscle fibre of itself will stretch under weight. The long head of the biceps where it crosses the capsule is not tense save under contraction. It is remarkably loose and that is the reason that it is not more frequently ruptured either in dislocation or fracture of the neck of the humerus, although we have seen this rupture of the long head of the biceps several times in both varieties of injury. Were these muscles together with the triceps behind responsible for the position of the head of the humerus in the glenoid, then the head of this bone except when these muscles were tense would always slip down from its normal position under the acromion. It is the shorter, more fibrous and shorter bellied supraspinatus and the short rotators, aided by atmospheric pressure, which prevents this drop and a paralysis of the suprascapular nerve, without paralysis of the

deltoid, will show this dropping nearly always. Reefing the capsule of the shoulder-joint to prevent recurrent dislocation is illogical. Reefing the tendons of the supraspinatus and the tendons of the infraspinatus and teres minor is the logical procedure for recurrent dislocation at the shoulder-joint.

Rarely, the subscapularis will also have to be tensed, but not often. Gentle passive motion, through a few degrees of arc, while the arm is in the abducted position, during the first ten days, following a dislocation, and then bringing the arm to the side with restriction and freedom from weight with gentle passive and active motion to the shoulder-joint for ten days longer will do away with the greater number of these recurrent dislocations of the shoulder-joint and will give us results which will not present Schultz's terrible statistical figures.

No. 1. KOCHER'S REDUCTION

Flexion of the forearm relaxes biceps and C. Brac. Extreme external rotation levers the post. surface of the great tuberosity against the rim of the glenoid.

No. 2. KOCHER'S REDUCTION

Keeping the flexion and external rotation, the elbow is swung across the chest. This levers the upper end of the humerus against the coracoid. A push upward on the elbow at the same time helps.

No. 3. KOCHER'S REDUCTION

The pressure against the elbow being continued, the arm is internally rotated by placing the hand on the opposite shoulder.

No. 1. OUR REDUCTION

Flexion of forearm and abduction to above a right angle and extreme ext. rotation.

105

No. 2. OUR REDUCTION

Traction in addition to the flexion of the forearm and the abduction. Traction is best supplied by a rubber band attached to a Collins hitch about the arm. The rubber band shown here is capable of a pull up to fifty pounds which is much in excess of need. Man power can be used, but the tube permits all manipulation to be made while still maintaining its pull and is steady.

No. 3. OUR REDUCTION

Abduction, traction, and external rotation having raised the head of the dislocated humerus on to the rim of the glenoid, internal rotation is accomplished by sweeping the arm down in front of the face to the side. This carries the head back in the glenoid. Note how easy this is with the rubber traction in place. Note that the fingers of the left hand are under the humerus and the thumb is over the acromian.

106